Effects of Cooking Fuels on Lung Function in Nonsmoking Women

JEFFREY R. JONES, M.S., M.P.H.
IAN T. T. HIGGINS, M.D.
MILLICENT W. HIGGINS, M.D.
JACOB B. KELLER, M.P.H.
The University of Michigan
School of Public Health
Department of Epidemiology
109 Observatory Street
Ann Arbor, Michigan 48109

ABSTRACT. A case-control study of 20- to 39-yr-old female participants in the Tecumseh Community Health Study compared use of cooking fuels and other factors in women from the highest and lowest quartiles of the lung function distribution. The forced expiratory volume in 1 second ($FEV_{1.0}$) was used as the index of ventilatory lung function. The use of a kitchen exhaust fan was significantly associated with low lung function. A larger proportion of women with low $FEV_{1.0}$ used gas for cooking, but this difference was not statistically significant.

CONCENTRATIONS OF NITROGEN OXIDES (NO, NO_2) and carbon monoxide (CO) were found to be higher in homes using gas than in homes using electricity for cooking.[1-3] Nitrogen oxide concentrations in gas kitchens were up to eight times those in electric kitchens.[3] Indoor pollutant levels were commonly higher inside than outside the house when the oven or stove was in use. For the average person, the gas kitchen probably provides the highest exposure to these pollutants. In fact, the EPA recommended maximum 1 hr concentration[4] for nitrogen dioxide of 500 $\mu g/m^3$ could be repeatedly exceeded in the average gas kitchen.[5]

There is evidence suggesting that persons who live in houses in which gas is used for cooking may have higher prevalence rates of respiratory symptoms, higher incidence rates of respiratory infections and lower ventilatory lung function than persons who live in houses in which electricity is used. Melia[6] found more cough, chest colds, and bronchitis in children from homes with gas stoves. Speizer[7] reported a slightly lower forced expiratory volume at 1 second ($FEV_{1.0}$) and a higher rate of acute respiratory disease in children living in homes with gas cooking. Hasselblad[8] found lower levels of $FEV_{.75}$ in 9- to 13-yr-old girls from homes with gas kitchens and Comstock[9] noted impaired $FEV_{1.0}$ and increased frequency of respiratory symptoms in nonsmoking men exposed to gas cooking in the home. He found no evidence of similar dysfunction in women. Conversely, in a 1-yr longitudinal study, Keller[10] found no significant difference in reported respiratory disease rates in persons with gas or electric kitchens.

Information collected in the Tecumseh Community

Health Study was used to test the hypothesis that nonsmoking women living in homes where gas is used for cooking have lower lung function than those living in homes where electricity is used for cooking. The Tecumseh Community Health Study is a longitudinal, epidemiologic study of chronic disease ongoing since 1959 in the population of Tecumseh, Michigan, the main purpose of which is to identify causes and precursors of cardiovascular and chronic respiratory diseases, diabetes mellitus, arthritis, and obesity.[11]

METHODS

A sample of 213 nonsmoking women, aged 20-39 yr and consisting of all persons in the highest and lower quartiles of the $FEV_{1.0}$ distribution, was drawn from tests conducted on the Tecumseh Community Health Study cohort in 1978 and 1979. A case control study design was used employing lung function data from the ongoing longitudinal study. Lung function values were expressed as $FEV_{1.0}$ percent of predicted. Predicted values were based on the linear regression of $FEV_{1.0}$ on age and height of asymptomatic nonsmoking women.[11]

Information about factors which might affect indoor air quality and pollutant exposures was obtained by telephone interview in 1980. Questions were asked about:

(a) primary and backup heating fuels

(b) primary and backup cooking fuels
  (1) time spent cooking
  (2) use of an exhaust fan while cooking

(c) presence of devices affecting indoor air quality (e.g., air conditioning, humidifiers, dehumidifiers)

(d) presence of smokers in the home

(e) age of the home

Questions were asked in 1980 but referred to exposures in 1978 and 1979. Thus the maximum recall period was 30 months. One interviewer (J.J.) did not know the subjects' level of lung function. Persons who could not be reached by phone were sent a questionnaire by mail.

The coded data were analyzed using the Michigan Interactive Data Analysis System.[12] Lung function was characterized as high or low FEV according to whether $FEV_{1.0}$ percent of predicted was in the highest or lowest quartiles of the distribution. Responses to questions (see above and Table 1) were either categorized (heating and cooking fuels, duration of exposure to cooking fuels, kitchen exhaust fan use, presence of devices affecting air quality, presence of smokers in the home, and socioeconomic status variables) or handled as continuous data (hours spent cooking per week, age of home), depending on the particular measures. Chi-square and Student's t tests were used to assess associations between lung function and the response variables. Odds ratios were calculated as measures of assocation. Odds ratios significantly greater than 1 indicate assocation of a factor with decreased lung function.

To examine the combined effects of various factors and their relative importance, the following multiple logistic regression model was employed:

$$\hat{p} = [1 + \exp(-a - \Sigma b_i x_i)]^{-1}$$

where $\hat{p}$ is the estimated probability of disease and x_i is the value of the i^{th} risk variable. Odds ratios approximate the relative risk for each factor, conditional upon the others remaining fixed, and are calculated as e^{b_i} where e is the natural logarithm base and b_i the estimated coefficients of x_i. The model was evaluated using only the three most important contributing variables.

RESULTS

A total of 102 women with low FEVs and 103 women with high FEVs were interviewed. The response rate was 96%. Mean ages were 29.3 and 28.9 yr, respectively. The frequencies of reporting selected exposures are shown in Table 1. Only kitchen exhaust fan use was significantly associated with low lung function ($P = .04$). Of those in the lowest quartile of $FEV_{1.0}$, 30.4% used gas for cooking compared to 22.3% of those in the highest quartile. This difference, though in the direction suggested by the hypothesis, did not reach the 5% significance level. Long-term exposure to gas cooking (more than 10 yr) followed the same trend. There was no difference in the mean number of hours spent cooking. The use of air conditioners, humidifiers, and dehumidifiers was more frequent among those in the higher FEV quartile, but the differences were not significant. A larger proportion of women with high FEV's were exposed to smokers in the home. Socioeconomic status, as measured by the subject's education level and income, was not significantly different in the two groups.

Table 2 shows the results of the multiple logistic regression analysis. Only variables with the largest or smallest relative risks and the smallest P values were included. Use of a kitchen exhaust fan was significantly associated with low lung function ($P = .01$, Odds Ratio = 2.63). Association of low FEV and gas cooking was marginally significant ($P = .07$). Use of a dehumidifier was inversely, but not significantly related to low FEV.

DISCUSSION

The primary purpose of this study was to examine relationships of cooking fuels with lung function in women. Interpretation of the marginal association seen in the logistic model requires consideration of some methodological issues. First, electric stoves were used three times more frequently than gas stoves. A preliminary survey had suggested that gas and electric stoves were used with equal frequency. Thus, the power to detect significant differences in fuel use between lung function categories was less than if there had been a more equal distribution of gas and electric cooking.

Table 1.—Percentage of Women with Selected Exposures by Quartile of $FEV_{1.0}$ Percent Predicted

Characteristic	Low FEV (N = 102)	High FEV (N = 103)	Difference	Odds Ratio	P (Two-Tailed)
Gas heat	55.9	60.2	−4.3	.84	0.53
Gas cooking	30.4	22.3	8.1	1.52	0.22
Exposure to gas cooking (> 10 yr)	16.7	10.7	6.0	1.67	0.61
Kitchen exhaust fan use	27.4	15.5	11.9	2.06	0.04
Gas cooking and exhaust fan use	4.9	2.9	2.0	1.72	0.54
Air conditioner	36.3	42.7	−6.4	0.76	0.34
Humidifier	50.0	55.3	−5.3	0.81	0.36
Dehumidifier	23.5	29.1	−5.6	0.75	0.36
Smokers in house	32.2	39.8	−6.5	0.76	0.34
Education > high school	43.1	47.6	−4.3	0.97	0.57
Income > $20,000/yr	43.1	40.8	2.3	1.10	0.87

Second, the effects of gas cooking on lung function observed by other researchers were slight. Any adverse effects of gas cooking are likely to be small in comparison to the effects of other adverse determinants of lung function such as smoking and occupation. The use of nonsmoking women precludes confounding or masking of the effect of gas cooking with this factor. Harmful occupational exposures are unlikely in this group of women. Third, the population studied may not be sensitive to the exposure of interest. For example, harmful effects of gas cooking might be greater in the very young or in those with severely impaired lung function. Alternatively, the duration of exposure to cooking in this population may be insufficient to show an effect. Current fuel use may also be a poor measure of long-term exposure. Fourth, $FEV_{1.0}$, the usual measure of obstructive lung disease, may be insensitive to detecting any effect of gas cooking on the lung.

The association of kitchen exhaust fan use with low lung function was unexpected. A causal link seems unlikely, but fan use may be more frequent in the low FEV group because of: (1) the sensitivity of these people to ambient pollution in general and gas combustion products in particular or (2) higher levels of pollution (from undetermined sources) making fan use desirable. Use of a fan was not related to the type of cooking fuel. Exhaust fans may serve as an indicator or index variable for another probably unmeasured factor. Further definition of this factor(s) would be an area for future research.

Air conditioners, humidifiers, and dehumidifiers all tended to be more common in the homes of women with high FEVs. Whether these devices actually improve air quality from a pollutant standpoint is arguable. They may be an indirect measure of a factor such as socioeconomic status, which is directly related to level of lung function, or they may reflect a greater concern with air quality and possibly other aspects of the physical environment.

Although some studies have shown an increased incidence of lung cancer[13] or decreased lung function[14] in nonsmokers exposed to the cigarette smoke of family members or co-workers, others have found no significant effect of nonsmoker's exposure to the smoking by family members.[15] The present study showed no significant effect on $FEV_{1.0}$ from exposure to smokers in the home. In fact, the Odds Ratio of 0.76 was less than might be expected for a potentially hazardous exposure.

No attempt was made to monitor actual indoor air pollutant burdens in the homes included in this sample and no such data were available for the community of Tecumseh. Measuring CO, NO_x, and particulates in a cross section of homes with various applicances affecting air quality would allow correlation of lung function with indoor air pollution and provide additional useful information.

A larger sample size may indicate that the use of gas stoves is related to low FEV as reported by others, but it is debatable whether the impact of these appliances on health is biologically significant. $FEV_{1.0}$ reduction of a few milliliters in a subgroup of the population may oc-

Table 2.—Multiple Logistic Regression of Low FEV

Characteristic	Odds Ratio	P (Two-Tailed)
Gas cooking	1.82	0.076
Kitchen fan	2.63	0.010[1]
Dehumidifier	0.64	0.116

cur in the absence of any real effect on the health of most individuals. Further research into the health effects of indoor air pollution is needed to determine whether impaired lung function is associated with the use of gas cooking or kitchen fans and, if so, to determine whether the association is causal and of any importance relative to exposure to other respiratory hazards.

Submitted for publication February 15, 1983; accepted for publication March 7, 1983.

Requests for reprints should be sent to: Jeffrey R. Jones, M.S., M.P.H., The University of Michigan School of Public Health, Department of Epidemiology, 109 Observatory Street, Ann Arbor, Michigan 48109.

REFERENCES

1. Wade, W. A.; Cote, W. A.; and Yocum, J. E. 1975. A study of indoor air quality. *J Air Pollut Cont Assoc* 25: 933–39.
2. Palmes, E. D.; Tomczyk, C.; and DiMattio, J. 1977. Average concentrations in dwellings with gas or electric stoves. *Atmospheric Environ* 11: 869–72.
3. Melia, R. J. W.; Florey, C. V.; and Darby, S. C. 1977. Differences in NO_2 levels in kitchens with gas and electric cookers. *Atmospheric Environ* 11: 1379–81.
4. Code of Federal Regulations. 1980. Vol. 40, Section 50.11, p. 525.
5. Budiansky, S. 1980. Indoor air pollution. *Environ Sci Tech* 14: 1023–27.
6. Melia, R. J. W. et al. 1977. Association between gas cooking and respiratory disease in children. *Br Med J* 2: 149–52.
7. Speizer, F. E.; Ferris, B.; Bishop, Y. M. M.; and Spengler, J. 1980. Respiratory disease rates and pulmonary function in children associated with NO_2 exposure. *Am Rev Respir Dis* 121: 3–10.
8. Hasselblad, V.; Humble, C. C.; Graham, M. C.; and Anderson, H. S. 1981. Indoor environmental determinants of lung function in children. *Am Rev Respir Dis* 123: 479–85.
9. Comstock, G. W.; Meyer, M. B.; Knud, J. H.; and Tockman, M. S. 1981. Respiratory effects of household exposures to tobacco smoke and gas cooking. *Am Rev Respir Dis* 124: 143–48.
10. Keller, M. D.; Lanese, R. R.; Mitchell, R. I.; and Cate, R. W. 1979. Respiratory illness in households using gas and electric cooking. *Environ Res* 19: 495–503.
11. Higgins, M. W.; Keller, J. B.; and Becker, M. 1982. An index of risk for obstructive airways disease. *Am Rev Respir Dis* 125: 144–51.
12. Fox, D. J., and Guire, K. E. 1976. *Documentation for MIDAS*. Ann Arbor, MI: University of Michigan.
13. Hirayama, T. 1981. Nonsmoking wives of heavy smokers have a higher risk of lung cancer: A study from Japan. *Br Med J* 282: 183–85.
14. White, J. R., and Froeb, H. F. 1980. Small-airways dysfunction in nonsmokers chronically exposed to tobacco smoke. *N Eng J Med* 302: 720–23.
15. Schilling, R. F.; Letai, A. D.; and Hui, S. L. 1977. Lung function, respiratory disease, and smoking in families. *Am J Epidemiol* 106: 274–83.